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ON THE MUTUAL COUPLING BETWEEN CIRCULAR RESONANT SLOTS

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Abstract

For near- and far-field microwave imaging purposes, array of circular resonant slots can be utilized to sample the electric field at a given reference plane. In general, the sensitivity of such array probes is impaired by the mutual coupling present between the radiating elements. The mutual coupling problem poses a design tradeoff between the resolution of the array and its sensitivity. In this paper, we investigate the mutual coupling between circular resonant slots in conducting ground plane both numerically and experimentally. Based on the analysis of the dominant coupling mechanism, i.e., the surface currents, various remedies to reduce the slots' mutual coupling are proposed and verified.

Introduction

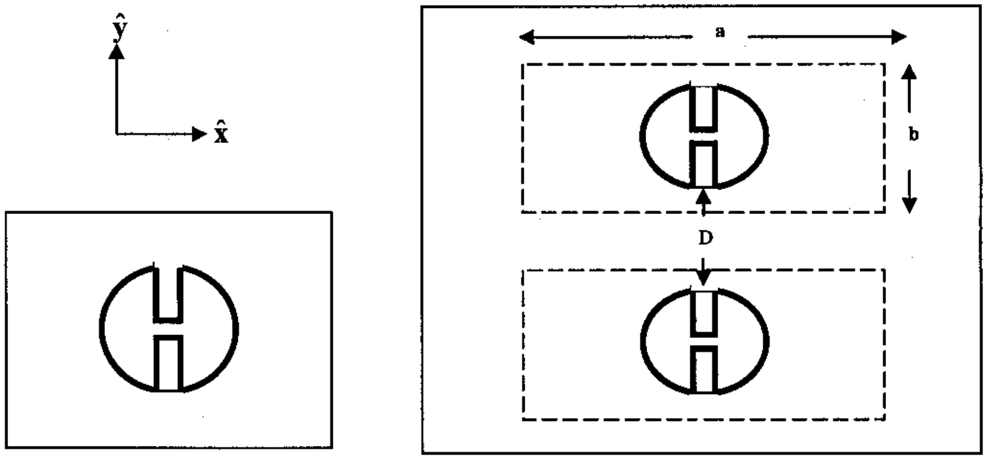
Slots in conducting ground planes are very attractive elements for the construction of imaging antenna arrays. Because they are easy to manufacture and possesses a low profile as flush-mounted antennas, such arrays are widely deployed in many applications [1]. Near- and far-field high resolution imaging probes can be realized using slot arrays. The shape, size, and configuration of the array are design parameters which typically depend on the required sensitivity and spatial resolution.

Circular resonant slots, although not as commonly used as rectangular slots, are potential candidates for the construction of the imaging probes. Circular resonant slot is basically a circular slot in which conducting strips are extended from the ground plane and routed within the slot area. The conducting strips should be routed such that they add an appropriate capacitive load to the inductive circular slot [2]. The shape and size of routed strips dictates the resonant frequency. In this context, the resonant circular slot is similar to the waveguide irises conventionally used to couple the cavity of Gunn oscillators to waveguide sections. A typical resonant circular iris which can be used as radiating slot is shown in Fig. 1(a).

For high resolution imaging applications, large arrays of closely spaced circular resonant slots can be utilized to sample the electric field at a given reference plane. However, the mutual coupling among the slots can severely impact the sensitivity of the imaging system. Hence, the need arises to study the mutual coupling between this type of slots.

Mutual coupling between rectangular slots on conducting plane and coupling reduction techniques have been the subject of treatment in numerous research (see [3] and the references therein). However, mutual coupling between resonant circular slots

has not been similarly addressed in past. This is mainly due to the complexity of their shapes. With the advancement in numerical modeling techniques, however, the interaction between circular resonant slots can be analyzed using commercially available software packages, i.e., HFSS® [4].



(a) (b)

Fig. 1: (a) A circular resonant slot, (b) two-element E-plane array of two waveguide-fed circular resonant slots.

In this paper, we investigate the mutual coupling between circular slots in conducting ground plane both numerically and experimentally. Based on the analysis of the dominant coupling mechanism, i.e., the surface currents, various remedies to reduce the slots' mutual coupling are proposed and verified.

Preliminary Results

The interaction between two circular resonant slots fed by apertures of rectangular waveguides as depicted in Fig. 1(b) is considered herein. Such arrangement is referred to as E-plane arrangement where the edge-to-edge interspacing between the slots is D. The slots resonate at 10.27 GHz. The slot radius is 3.75 mm and the width of the conducting strips is 1.7 mm with 0.4 mm air gap between them.

The normalized coupling coefficient between the slots is given by:

$$|C|^2 = \frac{|S_{12}|^2}{(1-|S_{11}|^2)(1-|S_{22}|^2)},$$

where S_{11}, S_{12}, and S_{22} are the scattering parameters referenced to the input of the waveguides.

HFSS was used to compute the scattering parameters at 10.27 GHz for the arrangement of Fig. 1(b). The normalized coupling coefficient between the slots as function of the interspacing distance is shown in Fig. 2. It is evident that the coupling coefficient (in dB) decreases linearly with increasing the distance between the slots. This linear behavior might be attributed to small electrical size of the radiating slot. For circular resonant slot of Fig. 1(a), the electric field is more concentrated in the middle of the slot around the air gap between the conducting strips. Consequently, there is such a

small area over which the interaction between the slots significantly dominates the coupled power from the other areas.

We remark that the linear behavior of mutual coupling will be quantitatively explained in the proceedings paper. Furthermore, experimental results will be provided. Finally, remedies to reduce the coupling between the slots will be proposed and verified.

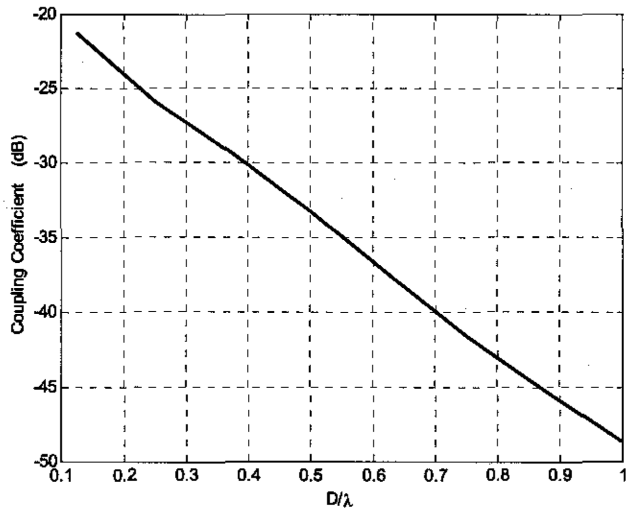


Fig. 2: Normalized coupling coefficient between the two slots arranged as shown in Fig. 1(b).

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